Applied Physics

Lecture #1

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Chapter#21

Applied Physics

- It is the study of basic laws of nature and their applications to modern technologies.
- Applied physics is intended for a particular technological or practical use. It is usually considered as a bridge or connection between physics and engineering.

Electric Charge

"*Electric charge is the physical property of matter that causes it to experience a force when placed in an electromagnetic field*"

- Charges are present in almost every type of body. All those bodies having no charges are the neutrally charged ones.
- **Where does charge come from?**

The electric charge on a body comes as a result of transferring of electrons from one body to another. This way one body has an excess and the other a deficiency of electrons

- **How is Electric Charge Measured?**

The electric charge is measured using coulomb.

- SI unit of charge is coulomb written as C.
- **Coulomb**: 1 coulomb is the quantity of charge transferred in one second. Given by:

$$\mathbf{Q = I.t}$$

Where,

Q is the electric charge

I is the electric current

t is the time.

Types of Electric Charge

There are two types of electric charge

- positive(+) charge
- negative(-) charge

Positive Charge:

Deficiency of electrons create a positive charge.

Negative Charge:

Excess of electrons create a negative charge.

- The two very basic natures of electric charges are

  Like charges repel each other.

  Unlike charges attract each other.

- The nature of charges is responsible for the forces acting on them .
- The charge on electron and proton is the same in magnitude which is 1.6×10^{-19} C.
- The difference is only the sign that we use to denote them, + and -.

Electric Field

- Electric charges produce electric fields

"An electric field is a region of space around an electrically charged particle or object in which an electric charge would feel force."

- The electric field exists at all points in space and can be observed by bringing another charge into the electric field.
- The electric field can be approximated as zero for practical purposes if the charges are far enough from each other.
- The electric field lines are defined as pointing *radially outward*, away from a positive charge, or *radially inward*, toward a negative charge.
- The magnitude of the electric field is given by the formula

$$E = F/q$$

- Unit of E is N/C.

where E is the strength of the electric field, F is the electric force, and q is the test charge that is being used to "feel" the electric field.

Electric Force

"*The repulsive or attractive interaction between any two charged bodies is called as an electric force*"

- The electric force between two electrons is equal to the electric force between two protons when placed at equal distances.
- **What is Coulomb's Law?**

Coulomb's law describes the amount of electrostatic force between stationary charges.

Coulomb's law states that:

"The value of the electrostatic force of interaction between two point charges is directly proportional to the scalar multiplication of the charges and inversely proportional to the square of the distance among them"

$$\vec{F} = K\frac{q_0 q_1}{r^2}$$

Where,

F is the electric force directed between two charged bodies

K is the constant of proportionality and its value is $8.99 \times 10^9 \mathrm{N \cdot m^2/C^2}$.

q0 and q1 are the amounts of charge on each body

r is the distance between the charged bodies

Electrical Force Examples

The examples of electric force are as mentioned below:

- The charge in a bulb.
- Electric circuits.
- Static friction between cloth when rubbed by a dryer.
- The shock that is felt after touching a doorknob.
- The electric force can also be viewed through current electricity like copper wiring that carries power to the whole building.
- The electrostatic force exhibits electric energy through static charges like cathode-ray tubes in TVs and electrostatic spray painting.

Properties of Electric Charge

The various properties of charge include the following:

- Conservation of Electric Charge
- Quantization of Electric Charge

Conservation of Electric Charge

“According to the principle of conservation of charges, the charges are neither created nor destroyed; they are only transferred from one body to the other”

For example:

when two objects, one having some charge and the other having no charge are made to come in contact with each other, the charge is transferred from the object possessing some charge to the object possessing no charge until the charged is equally distributed over the whole system. Here, no charge is created or lost and is only transferred from the one possessing an excess of charge to the other possessing a deficit.

Quantization of Electric Charge

"According to the principle of quantization of electric charge, all the free charges are integral multiples of a basic predefined unit which we denote by e"

Thus, the charge possessed by a system can be given as,

$$q = ne, \qquad n = \pm 1, \pm 2, \pm 3, \ldots,$$

Where n is any integer (zero, a positive or a negative number) and e is the basic unit of charge, that is, the charge carried by an electron or a proton.

- The value of e is 1.6×10^{-19}C.

Conductor:

a conductor is a type of material that allows the flow of charge (electrical current) in one or more directions. Materials made of metal are common electrical conductors

Insulator:

An insulator is a material that does not conduct electrical current. Insulating materials include paper, plastic, rubber, glass and air.

Semiconductor:

A semiconductor material has an electrical conductivity value falling between that of a conductor, such as metallic copper, and an insulator, such as glass.

Applications of Electric Force

Assignment work

Problems:

1. What must be the distance between point charge q1,26.0 µC and point charge q2 -47.0 µC for the electrostatic force between them to have a magnitude of 5.70 N?
2. A particle of charge +3.00 µC is 12.0 cm distant from a second particle of charge -1.50 µC. Calculate the magnitude of the electrostatic force between the particles.
3. What is the magnitude of the repulsive electrostatic force between two of the protons that are separated by $4.0*10^{-15}$ m?